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The Standard Deviation in the Weight of White Leghorn Eggs

(Technical)

BY

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THE STANDARD DEVIATION IN THE WEIGHT OF WHITE LEGHORN EGGS

The eggs laid by a hen vary in weight. Some of them are considerably heavier or lighter and some only slightly heavier, or lighter, than the mean or agerage weight. Table II shows the weight of the eggs laid by hen No. 315 during each month of her second laying year. The column to the left indicates the weights of the eggs, and the tally marks in the columns headed by the names of the months indicate the number of eggs laid during each month, arranged according to their weight. For example, in March this hen laid 3 eggs falling in the 53.5 gram class; 2 eggs in the 54.5 gram class, and so on. The heavy horizontal line is used to indicate approximately the mean egg weight for the year which lies between 56.5 and 57.5 grams. From this line of mean weight the eggs are dispersed or scattered more or less widely.

TABLE I.—Calculating the Standard Deviation of the Weight of Eggs Laid by Hen 315 as Shown by Table II.

Weight of Eggs in Grams	Number of Eggs	Product of Number of Eggs Multiplied by Weight	Square of the Weight Multiplied by the Number of Eggs
50.5	1	50.5	2550.
51.5	1	51.5	2652.
52.5	3	157.5	8268.
53.5	13	695.5	37209.
54.5	21	1144.5	62375.
55.5	27	1498.5	83167.
56.5	31	1751.5	98959.
57.5	30	1725.0	99187.
58.5	27	1579.5	92400.
59.5	25	1487.5	88506.
60.5	8	484.0	29282.
61.5	6	369.0	22693.
62.5	4	250.0	15625.
Total	197	11244.5	642873.

11244.5÷197=57.079, the mean weight of the eggs for the year. The square of 57.079 multiplied by 197 equals 641827. 642873—641827=1046. 1046÷197=5.309 $\sqrt{5.309}$=2.30, the standard deviation sought.

TABLE II.—Frequency Chart Showing Distribution of Eggs During the Year, Dec. 1921-Nov. 1922, Laid by Bird 315, Deviation in Weight of Eggs, Mean Weight, and Standard Deviation.

Weight Grams	Dec.(1921)	Jan(1922)	Feb	Mch	Apr	May	June	July	Aug	Sept	Oct	Nov	Number of Eggs
295													
305													
315													
325													
335													
345													
355													
365													
375													
385													
395													
405													
415													
425													
435													
445													
455													
465													
475													
485													
495													
505								1					1
515								1					1
525						1	11						3
535				///		1111	1111	///	/				13
545			/	//	/	1111	///	////	//	/	/		21
555			/	///	///	1111//	1111	///	/	/	//		27
565				1111//	1111	//	//	///	/	1111//	///	/	31
575				//	////	///	///	////	1111 1111	/	///	/	30
585				///	///	///	//	////	1111 /	///	//	/	27
595			/		1111	//		/	//	1111//	//	1111	25
605				/	/				//		/	///	8
615										///	///		0
625					/				/		/	/	4
635													
645													
655													
665													
675													
685													
695													
705													
715													
725													
735													
745													
755													
765													
775													
785													
Number of Eggs			3	21	23	24	24	24	25	23	18	12	197

Bird No. 315
Mean Weight of Eggs 57.079 Grams
Standard Deviation in Weight 2.30 Grams

Table III shows the weights of the eggs laid by hen No. 355 during her second laying season. By comparing Tables II and III it becomes evident that the egg weights are more widely scattered in the latter instance.

Standard Deviation

The extent of the scattering or dispersion is measured by the standard deviation which takes into consideration the amount of departure of each variate, (by "variate" is meant one of the individuals measured or weighed) as based on the mean or the arithmetical average of all of them. In this publication the standard deviations have been calculated by means of the

TABLE III.—Frequency Chart Showing Distribution of Eggs During the Year, Dec. 1921-Nov. 1922, Laid by Bird 355, Deviation in Weight of Eggs, Mean Weight, and Standard Deviation.

Weight Grams	Dec.(1921)	Jan.(1922)	Feb	Mch	Apr	May	June	July	Aug.	Sept	Oct	Nov	Number of Eggs
295													
305													
315													
325													
335													
345													
355													
365													
375													
385													
395													
405													
415													
425													
435													
445													
455													
465													
475													
485													
495													
505													
515				/			//						3
525							/	/		/	/		4
535						/	//						3
545				//	/	////	/	////		/	/		14
555					//		/	////	/				9
565				//	/	////	////	///		///	//		21
575				//	////	/	//	//	/	//	////	/	19
585			/	///	///	////	//	///	//	///	/	/	24
595				//	////		///	//	///	//	////	//	23
605			/	///	//	/	/		///	///	//	/	17
615		/		/	/	//		/	///	//	//	//	15
625		//	/	/			/		/		/	//	9
635				/		/			/		/	/	5
645		/	/						/	/		////	9
655					/					/			2
665													
675					/								/
685													
695													
705					/								/
715													
725													
735													
745													
755													
765													
775													
785													
Number of Eggs		4	4	18	21	20	21	21	16	19	20	15	179

Bird Number 355
Mean Weight of Eggs 58.768 grams
Standard Deviation in Weight 3.26 grams

following simple formula:*

Standard deviation $= \sqrt{\frac{\Sigma m^2 - na^2}{n}}$ in which "Σm^2" represents the sum of the squares of the independent measures or variates, "n" the number of measures or variates and "a" their arithmetical average or mean value.

For the purpose of illustrating the method of calculating the standard deviation in the weight of eggs the record of hen 315 is taken and the calculation presented in Table I, page 3, in full.

In the same way the standard deviation for hen 355 (Table III) has been found to be 3.26. The two values 2.30 and 3.26 enables one to compare the relative variability in the weight of the

*Phillips, Monthly Weather Review, March, 1922, p. 36.

eggs laid by hens 315 and 355, and as it is desirable to secure eggs that are uniform in weight this information may be of importance in connection with the selection of females when breeding for eggs of more uniform size.

The smaller the standard deviation the more closely do the eggs cluster about the mean weight, or in other words, the more uniform they are, taken as a whole.

Fowls Employed

The fowls employed in this work were standard bred Single Comb White Leghorns. Prior to the beginning of this experiment this strain of fowls had not been trapped or bred for egg production. The fowls were in six flocks designated as A, B, C, D, E, and F. Each female in A had one or more full sisters in flock B and vice versa. Likewise C and D were sisters and E and F were sisters. Flocks A, C, and E were well fed while young while flocks B, D, and F were fed rations low in protein and ash constituents so that the increase in live weight was slow. After laying began all six flocks were fed uniformly on a well balanced laying ration.

The data used in this discussion cover three years' of production for A and B, two years' for C and D, and one year's production for E and F. The laying year in all cases began December 1 and ended November 30. All eggs were weighed the day following that on which they were laid, and in this discussion double yolked eggs and those abnormally small were disregarded. Most of the eggs were weighed on a chainomatic balance, and the weights were recorded to one one-hundredth of a gram.

Standard Deviation as Influenced by the Age of the Fowl

Tables IV to IX, inclusive, give the standard deviations in the weight of the eggs laid by the various females in each flock.

The deviation varied from a maximum of $6.14 \pm .24$ in the case of bird 327 the first year to a minimum of $1.75 \pm .08$ in the case of bird 324 during the third year (See Table IV.)

There was no significant difference between the means for the second and third years, but the mean standard deviation for the first year was greater than during the later years. To illustrate the reason for this greater deviation during the pullet year, Table V is presented showing a typical pullet record.

TABLE IV.—Flock A (Well Fed While Young).

Band No. of Bird	Standard Deviation		
	First Year	Second Year	Third Year
301	3.61±.14	2.74±.10	2.23±.09
302	3.58±.12	1.96±.07	2.38±.08
308	2.06±.13	2.22±.08	2.23±.10
309	4.31±.15	2.35±.10	3.22±.14
311	3.84±.14	1.99±.07	2.16±.09
313	3.47±.13	3.26±.12	1.78±.09
315	4.65±.17	2.30±.08	3.33±.13
320	2.74±.12	2.56±.12	3.43±.18
322	2.80±.10	2.41±.09	2.32±.09
324	2.67±.10	2.25±.09	1.75±.08
325	3.24±.12	2.49±.10	2.39±.10
326	3.30±.14	4.25±.17	3.02±.12
327	6.14±.24	3.28±.12	2.57±.09
330	3.19±.17	2.24±.09	2.96±.12
331	2.82±.10	1.72±.08	2.12±.09
332	5.11±.18	2.71±.11	2.35±.09
333	2.96±.12	3.18±.15	2.86±.13
336	2.86±.12	1.99±.08	3.66±.15
342	2.57±.09	2.53±.09	3.04±.12
347	4.12±.17	2.82±.12	2.58±.10
351	3.17±.14	3.12±.11	3.60±.14
355	3.43±.13	3.26±.12	4.02±.15
356	4.63±.18	2.47±.09	2.46±.09
Unweighed Mean	3.53±.13*	2.61±.08	2.72±.05

*The probable error of the unweighed means in this and following tables has been calculated from the formula: $\frac{.6745 \cdot S.D.}{\sqrt{n}}$ considering each standard deviation as a variate.

By comparing Tables II, III, and V one may see that the distribution of egg weight is quite different during the first year of production or pullet year as compared with that of later years. With pullets the first eggs laid are small and there is a gradual and fairly regular increase in weight to the close of the year, but with mature hens the eggs laid in winter and spring are relatively large, with a gradual decrease to the minimum weight in summer and then an increase toward fall. This condition tends to throw the distribution closer to the mean in the case of the mature fowls.

Table VI shows the standard deviations of the weights of the eggs laid by flock B during the three years of the test.

The results as shown in Table VI agree with the results shown in Table IV in that the mean standard deviation for the

TABLE V.—Frequency Chart Showing Distribution of Eggs During the Year, Dec. 1920-Nov. 1921, Laid by Bird 305, Deviation in Weight of Eggs, Mean Weight, and Standard Deviation.

Weight Grams	Dec(1920)	Jan(1921)	Feb.	Mch	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Number of Eggs
29.5													
30.5													
31.5													
32.5													
33.5													
34.5													
35.5													
36.5													
37.5													
38.5													
39.5													
40.5			/										/
41.5			/										/
42.5			///										3
43.5			/	//					/				4
44.5				//	//								4
45.5			/	////	////	//							12
46.5			/	//////	///	///	///						18
47.5			/	////	////	//// ////	//	//// /		/			30
48.5				//	//// ///	////	////	//// /	/				26
49.5					/	/	////	////	///	//			16
50.5					//	////	//// /		///	////			21
51.5						//	/	///	////	///	///		15
52.5							/	/	//	///	//		9
53.5							/		////	//	/		8
54.5									/	///	////		8
55.5										/	/		2
56.5											/		/
57.5													
58.5													
59.5													
60.5													
61.5													
62.5													
63.5													
64.5													
65.5													
66.5													
67.5													
68.5													
69.5	Bird No. 305												
70.5	Mean Weight of Eggs 48.950 Grams												
71.5	Standard Deviation in Weight 2.97 Grams												
72.5													
73.5													
74.5													
75.5													
76.5													
77.5													
78.5													
Number of Eggs			9	24	25	27	24	20	18	20	12		180

first year was greater than that of succeeding years. There was no significant difference in the mean deviations for the second year and the third year, and there was no significant difference in the means for flock A as compared with flock B, showing that the poor ration fed the chickens in flock B had no measurable effect upon the standard deviation in the egg weight.

Tables VII and VIII show the standard deviation in the weight of the eggs laid by pens C and D.

TABLE VI.—Flock B (Poorly Fed While Young).

Band No. of Bird	Standard Deviation		
	First Year	Second Year	Third Year
303	3.17±.16	3.82±.15	3.24±.14
304	2.75±.12	2.44±.09	2.51±.12
305	2.97±.11	2.37±.10	2.37±.10
306	5.49±.19	3.18±.12	3.78±.20
312	2.74±.14	3.75±.19	3.45±.18
314	3.52±.14	1.71±.07	1.76±.08
316	4.39±.18	2.60±.09	3.10±.12
319	4.27±.16	2.34±.09	2.70±.11
323	3.98±.14	2.68±.10	2.69±.11
329	2.30±.11	2.49±.10	3.35±.14
334	2.35±.10	2.67±.11	2.44±.09
335	2.69±.12	2.65±.10	2.83±.11
337	5.57±.27	2.97±.12	2.79±.11
338	2.32±.11	2.38±.10	2.37±.09
340	2.89±.16	3.22±.12	2.90±.11
341	3.75±.17	2.92±.10	2.74±.10
345	3.03±.13	2.27±.08	2.14±.08
348	3.18±.17	2.40±.10	2.32±.13
350	3.54±.20	2.54±.11	2.89±.11
252	3.15±.13	2.64±.10	2.05±.09
354	2.66±.11	2.55±.10	2.87±.12
Unweighed Mean	3.36±.13	2.69±.07	2.72±.07

TABLE VII.—Flock C (Well Fed While Young).

Band No. of Bird	Standard Deviation	
	First Year	Second Year
401	4.28±.17	2.58±.10
402	3.90±.15	3.01±.11
403	4.02±.17	2.82±.11
404	3.48±.16	2.73±.11
406	3.26±.15	2.31±.09
407	3.69±.16	2.40±.09
409	5.57±.21	3.11±.13
411	4.54±.21	2.47±.10
415	2.96±.12	2.46±.10
419	2.59±.10	2.75±.11
420	3.24±.12	2.45±.11
421	2.42±.09	1.81±.07
422	3.28±.17	2.68±.14
424	4.87±.16	2.57±.09
428	2.84±.12	3.14±.11
431	3.39±.14	2.30±.09
432	3.04±.12	3.39±.13
434	2.56±.10	2.54±.11
435	3.97±.13	2.38±.08
Unweighed Mean	3.57±.13	2.62±.05

TABLE VIII.—Flock D (Poorly Fed While Young).

Band No. of Bird	Standard Deviation	
	First Year	Year Second
405	3.84±.19	3.43±.14
408	4.31±.18	3.74±.16
410	3.39±.14	3.46±.14
413	4.31±.20	2.09±.11
416	2.54±.11	2.23±.08
418	2.72±.11	2.16±.08
423	3.75±.16	2.40±.10
425	3.53±.13	3.52±.16
426	3.17±.14	2.43±.09
427	2.99±.11	2.37±.09
429	2.07±.11	2.45±.10
436	3.15±.12	3.15±.10
437	4.54±.19	3.00±.13
438	3.23±.13	2.24±.14
439	2.90±.10	2.26±.09
440	3.27±.15	3.40±.15
441	3.12±.14	2.48±.09
442	3.36±.15	3.11±.12
443	4.55±.28	3.06±.12
Unweighed Mean	3.41±.10	2.73±.12

Comparing the unweighed means for flocks C and D for the first and second years respectively it is seen that there is no significant difference due to the rations fed prior to maturity. The results with C and D agree with the results derived from flocks A and B in that the standard deviations for the first year were greater than for the second.

Table IX gives the standard deviation in the weight of the eggs laid by flocks E and F.

Table IX shows that the unweighed mean standard deviation for Flock E was slightly greater than for Flock F, and in this connection it is interesting to bring together the means for the six flocks. This has been done in Table X.

TABLE IX.—Standard Deviation in the Weight of Eggs Laid by Flock E (Well Fed While Young), and Flock F (Poorly Fed While Young).

Flock E		Flock F	
Band No. of Bird	First Year	Band No. of Bird	First Year
500	2.62±.10	530	2.71±.09
501	2.86±.12	551	2.95±.12
502	2.75±.11	552	2.75±.10
503	3.29±.14	553	2.83±.11
504	3.03±.11	554	1.52±.09
506	3.64±.13	555	3.64±.14
507	2.78±.10	557	2.69±.12
508	2.98±.14	558	2.48±.09
510	3.07±.13	559	3.47±.12
511	2.63±.10	560	3.19±.13
512	3.32±.16	561	2.14±.08
513	2.87±.11	562	2.04±.09
514	3.52±.12	563	2.93±.11
515	2.69±.10	565	2.79±.10
516	1.89±.08	566	3.05±.12
517	3.26±.12	567	4.31±.25
518	2.63±.11	568	2.60±.09
519	2.28±.08	569	2.84±.11
520	3.83±.10	570	1.82±.07
521	2.50±.09	571	2.04±.08
522	1.87±.07	572	2.33±.10
523	3.50±.13	573	3.79±.18
524	3.28±.12	574	2.31±.11
525	2.17±.10	575	2.35±.09
526	2.97±.11	576	2.42±.11
527	3.50±.12	577	3.24±.13
528	2.54±.10	578	3.30±.13
529	3.23±.11	579	3.38±.13
550	3.90±.14	580	2.36±.10
532	3.72±.15	581	2.56±.10
533	2.97±.13	582	3.18±.17
534	3.19±.12	584	2.54±.10
535	3.28±.12	585	2.90±.12
536	2.58±.09	586	3.14±.11
537	2.87±.11	587	3.04±.12
538	4.06±.15	588	3.04±.13
539	3.70±.15	589	2.64±.10
540	4.23±.16	590	2.94±.12
541	2.10±.08	591	2.86±.11
542	3.35±.13	592	3.21±.14
543	2.81±.10	593	2.41±.11
544	4.20±.19	594	2.27±.08
545	2.61±.10	595	2.36±.10
546	1.95±.07	596	2.83±.12
547	3.54±.14	597	3.11±.11
548	2.91±.11	598	2.91±.13
549	2.36±.09	599	3.03±.20
		600	3.08±.23
Unweighed Mean	3.00±.06		2.80±.05

TABLE X.—Comparison of Means for the Six Flocks.

Flock	Standard Deviation		
	First Year	Second Year	Third Year
A	3.53±.13	2.61±.08	2.72±.05
B	3.36±.13	2.69±.07	2.72±.07
Difference	+.17±.18	—.08±.10	.00±.08
C	3.57±.13	2.62±.05	
D	3.41±.10	2.73±.12	
Difference	+.16±.16	—.11±.13	
E	3.00±.06		
F	2.80±.05		
Difference	+.20±.08		

In no instance are the differences significant, with possibly an exception in the case of flocks E and F in the pullet year. The fowls well fed while young began to lay at an earlier age than their poorly fed sisters, and as the author has already shown that the younger the bird at the time of laying the first egg the smaller the first few eggs that are laid will be* it would be natural to expect a slight increase in the standard deviation in flocks A, C, and E due to this factor.

It is evident from the data submitted in Table X that the manner of feeding the chickens while young had no measurable influence on the standard deviation in the weight of the eggs laid by the mature females.

The Standard Deviation in the Weight of Eggs as Influenced by the Season of the Year

Do eggs fluctuate more from their mean weight at one season of the year than at another? To answer this question the deviation has been calculated for all six flocks for the laying season of 1922-1923. This was the third year of laying for flocks A and B, the second year for flocks C and D, and the first year for flocks E and F. The results of this computation are shown in Table XI.

*Bul. 182, p. 7. W. Va. Agr'l Exp't Station, August, 1923.

TABLE XI.—Standard Deviation in the Weight of Eggs Laid During Different Months of the Year.

Month	Flocks A and B			Flocks C and D			Flocks E and F		
	Number of Eggs Laid	Mean Wgt. of Eggs	Standard Deviation	Number of Eggs Laid	Mean Wgt. of Eggs	Standard Deviation	Number of Eggs Laid	Mean Wgt. of Eggs	Standard Deviation
Dec. 1922	32	60.219	3.01±.25	109	58.665	3.67±.17	77	42.773	1.88±.10
Jan. 1923	35	59.271	1.90±.16	161	58.351	3.51±.13	472	46.845	4.47±.09
Feb. 1923	269	58.853	3.65±.11	316	57.858	4.15±.11	808	49.587	3.03±.05
Mch. 1923	816	58.409	3.53±.06	703	57.510	3.95±.07	1622	50.801	3.23±.04
Apr. 1923	899	57.457	3.71±.06	838	56.465	4.02±.07	1822	51.085	3.13±.03
May 1923	909	55.929	3.48±.06	862	54.903	3.99±.06	1919	51.773	2.95±.03
June 1923	767	54.763	3.61±.06	745	53.805	4.03±.07	1799	51.454	3.44±.04
July 1923	835	55.058	3.73±.06	779	53.963	3.88±.07	1848	52.068	3.45±.04
Aug. 1923	714	54.979	3.58±.06	582	54.768	3.84±.08	1419	52.438	3.66±.05
Sept. 1923	486	56.053	3.72±.08	334	56.311	4.17±.11	1230	53.785	3.63±.05
Oct. 1923	127	57.484	3.46±.15	58	56.983	3.99±.25	602	55.135	3.82±.07
Nov. 1923	6	59.166	.91±.18	None	None	None	256	56.279	3.32±.10

If the results be disregarded where the number of eggs laid in a month was small, Table XI shows that there was but little difference in the standard deviation during the different months of the year. During May, the month of maximum egg production, the deviation was slightly smaller than earlier or later, but this difference is too small to be significant except with flocks E and F.

The deviations for flocks C and D average larger than for either flocks A and B or for flocks E and F. The author is unable to account for the greater variability in the weight of the eggs laid by these fowls.

Correlation Between the Number of Eggs Laid by a Bird and the Standard Deviation in the Weight of the Eggs

Is there any connection between the number of eggs that a hen may lay in a season and the extent of their fluctuations in weight? To answer this question the correlations have been calculated and the results are presented in Table XII.

TABLE XII.—The Mean Number of Eggs Laid per Bird, the Mean Standard Deviation in the Weight of Eggs, and the Correlation Between the Number of Eggs Laid and the Standard Deviation of Their Weight.

Flock		First Year	Second Year	Third Year
A	Number of annual records	23	23	23
	Mean number of eggs laid	147.00 ±4.47	151.70 ±3.65	138.17 ±3.40
	Mean standard deviation	3.53 ± .13	2.61 ± .08	2.72 ± .05
	Coefficient of correlation	+.384± .119	+.035± .140	+.052± .140
B	Number of annual records	21	21	21
	Mean number of eggs laid	121.29 ±5.15	150.05 ±2.97	129.52 ±3.77
	Mean standard deviation	3.37 ± .13	2.69 ± .07	2.73 ± .07
	Coefficient of correlation	+.212± .134	—.151± .137	—.155± .137
C	Number of annual records	19	19	
	Mean number of eggs laid	140.00 ±4.58	146.68 ±3.28	
	Mean standard deviation	3.57 ± .13	2.62 ± .05	
	Coefficient of correlation	+.261± .144	+.087± .054	
D	Number of annual records	19	19	
	Mean number of eggs laid	125.06 ±4.87	142.21 ±4.36	
	Mean standard deviation	3.41 ± .10	2.74 ± .12	
	Coefficient of correlation	—.117± .163	+.226± .144	
E	Number of annual records	47		
	Mean number of eggs laid	155.75 ±2.34		
	Mean standard deviation	3.00 ± .06		
	Coefficient of correlation	.000± .098		
F	Number of annual records	48		
	Mean number of eggs laid	167.40 ±3.33		
	Mean standard deviation	2.80 ± .05		
	Coefficient of correlation	.068± .097		

Table XII shows that none of the coefficients of correlation are significant with the exception of Flock A for the first year, hence it would appear that there is little or no relationship between the number of eggs that a hen may lay and the standard deviation in the weight of the eggs when the standard deviation is based on the production for an entire year.

Correlation Between the Standard Deviation in the Weight of the Eggs Laid by the Same Fowl from Year to Year

If a fowl lays eggs which have a relatively high or low standard deviation in weight, will this relatively high or low standard deviation persist during later years? To answer the question the coefficients of correlation have been calculated and the results are shown in Table XIII.

TABLE XIII.—Coefficient of Correlation in the Standard Deviations in the Weight of Eggs During Different Years.

Flock		Deviation Pullet Year Subject; Deviation Second Year Relative	Deviation Second Year Subject; Deviation Third Year Relative
A	r=	+.194±.135	+.360±.122
B	r=	+.195±.142	+.700±.075
C	r=	+.223±.147	
D	r=	+.662±.087	

All of the coefficients are positive. Two of them are strongly significent. The results taken as a whole would seem to indicate that the degree of deviation tends to persist from year to year. On the other hand the wide variation in the magnitude of the coefficients indicates that the deviation may be affected by forces other than those which bring about the primary deviation. It seems probable that the deviation as measured is the resultant of various influences. Some of these may be inherent, others may be the effect of varying environmental conditions which affect not only the number of eggs but also their weight.

Inheritance

Is the degree of deviation in egg weight an inheritable characteristic? The data available are too scanty to answer this question. Breeding experiments should be conducted selecting for high and low variability in egg weight.

Abnormal Deviations

Table XIV gives the record of bird 509 for her pullet year. During the first six months no unusual condition is evident, and the maximum frequency was in the 48.5 gram class. Later in the year the eggs became much heavier, and the maximum frequency was in the 64.5 gram class. The record possibly may indicate that this bird had two ovaries, one functioning during the first part of the season and the other later.

TABLE XIV.—Frequency Chart Showing Distribution of Eggs During the Year, Dec. 1922-Nov. 1923, Laid by Bird 509, Deviation in Weight of Eggs, Mean Weight, and Standard Deviation.

Weight Grams	Dec.(1922)	Jan.(1923)	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct	Nov.	Number of Eggs
29.5													
30.5													
31.5													
32.5													
33.5													
34.5													
35.5													
36.5													
37.5													
38.5													
39.5													
40.5		1			1	1							2
41.5													1
42.5		II				II							2
43.5		I											3
44.5		III	I	I	III	III	II						13
45.5		II		IIII I	II		III						13
46.5			LHI III	IIII	LHI	I	II						20
47.5		LHI	III	LHI	IIII	LHI I	I	II					26
48.5			II	II	III	III		III					13
49.5			II	I	III		III	I					10
50.5			I	I		I	LHI	II	I				9
51.5							I	I					2
52.5								I					2
53.5													
54.5													
55.5							I	I					1
56.5													1
57.5													
58.5													
59.5								I	I	I			1
60.5									I				1
61.5								I	I				2
62.5									I				2
63.5									III				3
64.5								I	I	I			2
65.5								I					1
66.5										I			1
67.5													
68.5													
69.5	Bird Number 509.												
70.5	Mean Weight of Eggs 50.465 Grams.								I				1
71.5	Standard Deviation in Weight 6.51 Grams												
72.5													
73.5													
74.5													
75.5									I				1
76.5													
77.5										I			1
78.5													
Number of Eggs		14	17	20	21	17	18	15	11	3			136

Table No. XV is the record for bird 583 during her pullet year. It is to be observed that the bird laid only 31 eggs, and that the standard deviation in their weight was 7.10 grams or about twice the normal.

TABLE XV.—Frequency Chart Showing Distribution of Eggs During the Year, Dec. 1922-Nov. 1923, Laid by Bird 583, Deviation in Weight of Eggs, Mean Weight, and Standard Deviation.

Weight Grams	Dec (1922)	Jan (1923)	Feb	Mch.	Apr	May	June	July	Aug.	Sept.	Oct.	Nov.	Number of Eggs
29.5				/									/
30.5													
31.5													
32.5													
33.5													
34.5													
35.5				/									/
36.5			/										/
37.5									/				/
38.5													
39.5							/			//			3
40.5													
41.5													
42.5			/					/					2
43.5													
44.5			/								/		/
45.5				/									2
46.5			/	/						/	/		2
47.5			/	/									2
48.5			/							/	/		3
49.5			/	/						///			6
50.5				/						/			2
51.5													
52.5			/										/
53.5													
54.5													
55.5											/		/
56.5													
57.5													
58.5								/					/
59.5													
60.5													
61.5													
62.5			/										/
63.5								/					/
64.5													
65.5													
66.5													
67.5													
68.5													
69.5	Bird Number 583												
70.5	Mean Weight of Eggs 48.113 Grams.												
71.5	Standard Deviation in Weight 7.10 Grams.												
72.5													
73.5													
74.5													
75.5													
76.5													
77.5													
78.5													
Number of Eggs			8	8			1	3	1	7	3		31

The Standard Deviation in the Weight of Different Parts of Eggs

Possibly throwing some light on the causes for fluctuations in egg weight it is interesting to determine whether different parts of an egg vary in weight uniformly or whether the fluctuations are mainly in some one portion.

In bulletin No. 166 of this station the weight of the eggs laid by certain hens and the weight of the yolks of these eggs are reported. The yolks were separated by breaking the eggs into a colander which permitted the major portion of the white to drain away, then carefully transferring the unbroken yolk to a piece of filter paper where it was rolled about, by lifting the edges of the paper, so that the remainder of the white would be absorbed, then transferring to a dish and weighing quickly.

The records presented here pertain to the eggs laid by four birds during the months from March to July both inclusive during 1915 and 1916, the former year being the pullet year for all four fowls.

Table XVI shows the mean weight of the eggs, the yolks, and the white and shell, together with the standard deviations, and the coefficients of variation.

Although somewhat foreign to the present study it is important to observe that the increase in the size of the yolks for all four birds from the first to the second year was relatively much greater than the increase in the weight of the remaining portions of the eggs. Stated differently the percentage of the eggs that was yolk was greater the second year than the first. This may be one reason why pullet eggs are generally found to be unsuitable for hatching, not only the eggs being small, but the yolks being relatively small for the size of the eggs.

Considering now the coefficients of variation it is seen that the variability in the weight of the yolks is slightly greater than the variability in the weight of the eggs or in the weight of the white and shell. It is difficult to understand why this should be, as the development of the yolk is a process extending over several days, while the secretion of the white and the formation of the shell and shell membranes is a very much shorter process, and it would be logical to expect that the result of this shorter process would be the more variable provided that the fluctuations in the weight of the eggs and its parts are due to environmental conditions. This result agrees, however, with that obtained by Jull* who found that "egg weight is the least variable; albumen weight slightly more variable than egg weight; yolk weight considerably more variable than albumen weight; and shell weight the most variable."

What are the factors that bring about fluctuations in the weight of eggs? The data that has been presented in this publication throws but little light on this general question.

Factors Influencing the Weight of Eggs

It will be of interest at this place to review briefly the factors that have a pronounced and well authenticated effect upon the weight of eggs.

*Poultry Science Vol. III. No. 3 (1924)

TABLE XVI.—Comparisons of Weight of Eggs, Yolks, Whites and Shells, Standard Deviations, and Coefficients of Variation.

Factors Compared	Bird 625 a		Bird 694 a		Bird 588 a		Bird 581 a	
	1915	1916	1915	1916	1915	1916	1915	1916
Number of eggs	69	68	56	51	65	52	62	70
Mean weight of eggs	55.73±.20	57.53±.17	53.51±.25	55.83±.31	49.12±.16	51.36±.28	56.66±.23	57.43±.22
Mean weight of yolks	17.32±.08	18.75±.05	16.40±.11	18.57±.13	15.56±.06	16.94±.10	16.82±.10	19.09±.07
Mean weight of albumen and shell	38.41±.14	38.78±.15	37.11±.17	37.25±.33	33.56±.11	34.42±.20	35.84±.18	38.35±.13
Standard deviation in weight of eggs	2.43±.14	2.13±.12	2.81±.18	3.37±.23	1.88±.11	3.00±.20	2.72±.16	2.69±.15
Standard deviation in weight of yolks	1.02±.06	.66±.04	1.21±.08	1.33±.09	.76±.04	1.11±.07	1.22±.07	.91±.05
Standard deviation in weight of albumen and shell	1.70±.10	1.79±.10	1.92±.12	2.40±.16	1.33±.08	2.11±.14	2.14±.13	1.56±.09
Coefficient of variation in weight of eggs	4.36±.25	3.70±.21	5.25±.33	6.04±.40	4.83±.29	5.84±.40	5.17±.31	4.69±.27
Coefficient of variation in weight of yolks	5.90±.34	3.49±.20	7.38±.47	7.15±.48	4.87±.29	6.57±.43	7.26±.44	4.75±.27
Coefficient of variation in the weight of the albumen and shell	4.43±.25	4.61±.27	5.18±.33	6.43±.43	3.97±.23	6.13±.41	5.98±.36	4.07±.23

In the first place egg size is a breed characteristic; at one extreme are the Bantams with their small eggs and at the other the Minorcas with their large eggs. The size of the eggs is also an individual characteristic that persists from year to year. In other words in the same breed certain birds habitually lay large eggs and other birds lay small eggs.

The age of the fowl has an influence on the weight of the eggs. The mean weight of the eggs laid during the second year of production in this experiment was eleven per cent greater than during the first year, and the increase from the second to the third year was two per cent.

Egg weight is intimately associated with body weight. As the pullet becomes heavier the eggs become heavier, and even in the case of the mature females the heaviest eggs are generally laid in winter or early spring when the hens are heaviest. There also seems to be a relationship between the mean weight of a bird and the mean weight of the eggs laid by that bird.

Table XVII shows the correlation between the mean weight of the birds and the mean weight of the eggs laid by these birds based on the records of the six flocks. The mean weight of the birds was based on monthly weighings throughout each year for each bird.

TABLE XVII.—Correlation Between the Mean Body Weight of the Birds and the Mean Weight of the Eggs Laid by the Same Birds.*

Flock	Year	Correlation
A C E	First	$r = +.418 \pm .059$
B D F	First	$r = +.164 \pm .070$
A C	Second	$r = +.433 \pm .084$
B D	Second	$r = +.528 \pm .077$
A	Third	$r = +.328 \pm .125$
B	Third	$r = +.553 \pm .102$

In every case the coefficient is positive and in most cases, strongly significant, and shows that the heavier birds in these flocks laid, in general, the heavier eggs.

If this result should be found to agree with the results obtained with other strains and breeds it would enable a breeder to modify quickly the size of the eggs laid by his flock so as to meet his market requirements.

*Table XVII is based on 3,636 body weights and 43,809 egg weights.

The weight of the eggs laid by a bird depends to a certain extent upon the rate of production. The author has shown in bulletin No. 182 of this station that the more eggs laid by a flock of fowls during any particular month the smaller are the eggs for that month, and vice versa. On the other hand a bird that is a prolific layer is as apt to lay as heavy eggs as a bird that is a poor layer. This is shown by Table XVIII.

TABLE XVIII.—Correlation Between the Number of Eggs Laid by a Fowl in a Year's Time and the Mean Weight of the Eggs.

Flock	Year	Correlation
A C E	First	$r = -.225 \pm .068$
B D F	First	$r = +.177 \pm .069$
A C	Second	$r = +.260 \pm .097$
B D	Second	$r = -.021 \pm .107$
A	Third	$r = +.015 \pm .140$
B	Third	$r = -.287 \pm .135$

Three of the coefficients are positive and three are negative, and none of them, with the exception of A C E for the first year, are significant. Hence we may conclude that the number of eggs that a hen may lay has no connection with their average size. The characters, number of eggs, and egg size are separate and distinct.

The ration has an influence upon the size of the egg. In bulletin 145 of this station the author has shown that a ration that is too scanty in amount, or one which is improperly balanced has a tendency to reduce the size of the eggs.

The factors enumerated above as affecting the weight of eggs throw but little light on the reason for the fluctuation in the weight of eggs as it takes place from day to day. In bulletin No. 166 of this station it has been shown that if a hen lays for several days in succession and then misses for a day or more, the first egg of the series is generally the heaviest and that there is a fairly regular and gradual decrease in the weight of the eggs toward the end of the series, the last egg being the smallest. This result can be explained by the assumption that the formation of egg substance takes place at a fairly uniform and regular rate during the period when the bird is in production. Now if the normal or natural weight of the egg laid by a

bird is greater than the amount of egg substance that can be elaborated by the bird in twenty-four hours then one or more of three things may happen. First the size or weight of the eggs may become smaller from day to day. There is an abundance of data to show that this takes place normally with most fowls. Secondly, the eggs may be laid later and later each day, the bird laying the first egg of the series say at 9 o'clock in the morning, the second egg at 10 o'clock the next day and so on, later and later, until a day is skipped entirely. That this is a matter of common occurrence is known to all who trap-nest fowls. Thirdly, the bird may cease laying for a day or more until she catches up with her daily program of production.

Based on this conception of the reason for the usual fluctuations in egg weight it appears probable that the smaller the decrease in the weight of the eggs laid by a certain bird from day to day, the better able that bird is to continue to lay without interruption. From this standpoint the standard deviation in the weight of eggs should be negatively correlated with the annual production, when this deviation is based on the weight of the eggs laid during such a short period of time that it is not masked by extraneous influences.

If the fluctuations in egg weight from day to day are associated with the number of eggs or the fecundity of the bird it should be possible to work out a method for predicting the productive capacity by a study of these fluctuations, and it is the purpose of the author to reexamine the data on which this bulletin is based with this end in view.

A decrease in egg weight from day to day, laying later and later each day, and occasionally missing one or more days when no egg is laid are the results of the inability of the birds to build up enough egg substance in twenty-four hours for the full sized daily egg. From this standpoint anything which will decrease the variability in egg weight should increase the number of eggs which may be laid, and it would appear that further study of the standard deviation in the weight of eggs may be of great value when carried on in connection with investigations in feeding and breeding fowls for increased production.